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Status of Pepper Farming and Flower Composition of Different Pepper Varieties in Sarawak

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ABSTRACT

Pepper (*Piper nigrum* L.) is one of the most important cash crops in Sarawak. The productivity of pepper is consistently low due to the low yield of berry production. One of the major problems of pepper production is inconsistent flowering time. This is due to the morphology and inheritance of functional male, female and hermaphrodite (bisexual) flower in *P. nigrum* which affect the productivity of pepper. For the exploitation of pepper for its maximum production, the detailed of flower development and flower composition are important factors to be considered. A field survey was conducted to determine the status of farming practices and problems encountered by the farmers. The study was also done to determine the composition of flower which influenced the consistency of berry production in *P. nigrum* in Sarawak. Surveys were conducted at 18 pepper farms in Sarawak to determine the composition of flowers in different types of Sarawak pepper varieties which are Kuching, Semenggok Aman and Semenggok Emas. Nine spikes were harvested in each pepper vine. Three pepper vines were selected randomly for each variety. The spikes were then observed under 3D Keyence microscope to determine the number of flowers of each type of flower. The survey on the farming practices were also conducted. The composition of flower was found to be varied between varieties. 'Kuching' variety had less hermaphrodite flower when compared to 'Semenggok Aman' and 'Semenggok Emas' varieties. In addition, a proportion of 29% farmers had encountered root rot disease problem in their farm, while 21% stated that unsynchronisation of berries production in each harvesting time as a major problem.

Keywords: Flower composition, Sarawak pepper and berries production

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INTRODUCTION

Pepper mostly cultivated for its fruit, and widely known as the "king of spices" and "black gold" especially among the farmers (Ravindran, 2000). Pepper is known for their extensive culinary usages and has been used enormously in food seasoning as the flavour and its pungency blends well with most savoury dishes. The history of pepper cultivation in Malaysia was believed to have started in early 10th to 11th century when the south Indian kings started to expand their empire (Ravindran, 2000). In East Malaysia, the grow of pepper cultivation had been reported in 1840 where the Chinese settlers actively grew black pepper in Bau, Baram, Trusan and Limbang, in the state of Sarawak.

The cultivation of pepper area and the export value are increasing and becoming part of Malaysia's economic profit where pepper price is the significant determinant of the total revenue of Malaysia particularly for the state of Sarawak. Until then, pepper cultivating is the only source of livelihood for majority of the pepper farmers in the state (Kiong et al., 2010). Malaysia is still placed fifth among the world largest producers of peppers by representing 5.9% of total production in the world with 31,7073 tonnes during the year 2018 (Malaysian Pepper Board, 2018).

Malaysian Pepper Board (2013) reported that there were no wild varieties or land races of pepper but only cultivated varieties. Since it was originated from South Western of India, prior to year 1957, there were only two cultivated varieties of pepper first reported in Sarawak, which is 'Sarikei' and 'Kuching'. Until then, 'Kuching' became the cultivar of choice by farmers and known as the traditional cultivar. It is more vigorous in growth and produces much high yield as compare to 'Sarikei'. After several years, 'Semenggok Perak', 'Semenggok Emas' and 'Semenggok Aman' were released by Malaysian Pepper Board (MPB) in 1988, 1991 and 2006 respectively. However, currently there are three recommended cultivars and grow by most farmers in Sarawak which was 'Kuching', 'Semenggok Emas' and 'Semenggok Aman'. Each of these cultivars has different characteristic. Therefore, prior to its cultivar origin, Malaysia black pepper is known as 'Sarawak pepper' among the world traders over the decade.

Despite its popularity as a well known cultivar, the productivity of pepper is consistently low due to the low yield of berry production. The production of pepper for the past 10 years was inconsistent and farmers also encountered several problems in their farms. The yield was affected due to pests and diseases with the major problems such as 'Phytopthora foot root' caused by *Phytopthora capsici*, 'black berry' or anthracnose caused by *Colletotrichum capsici*, *C. gloeosporioide*, and *C. piperis*, and 'slow decline' a disease complex between the root-knot nematods (*Meloidogyne* spp) and the fungus *Fusarium* spp. (Malaysian Pepper Board, 2013).

Other than that, Khew (2019) also stated that the inconsistent flowering time in *P. nigrum* could be one of the

reasons for low yield of peppers. This is due to the morphology and inheritance of functional male, female and hermaphrodite (bisexual) flower in *P. nigrum* which affect the productivity where fruit ripening is not uniform even within a spike. For the maximum production of pepper, the detailed of flower development and composition should be considered due to the non-synchronous nature of flower development. Therefore, the objective of the study was to determine the composition of flower which influenced the consistency of berry production in *P. nigrum* in Sarawak.

MATERIALS AND METHODS

Survey on the Farming Practices

The survey was covered in the seven areas in Sarawak which were in Kuching, Serian, Sri Aman, Sarikei, Bintangor, Julau and Miri. Sampling respondents to represent each district and 18 selected pepper farmers surveyed in these areas were based on prior information provided by the MPB. Data were collected through face-to-face interviews based on questionnaires that include farmers ethnicity, education level, year of farm establishment, total of pepper vines, types of planted cultivar and the products that they produce. All of this information was used to conclude their farming status. Meanwhile, the other information about their monthly maintenance, the problems encountered the most and the action taken would be concluded as problems and management status from each farmer. The data were analysed by using Statistical Package for the Social Sciences (SPSS) software.

Spike Selection and Morphological Observation

The observations of flowers in pepper crop were carried out in 18 pepper growing farms around Sarawak, Malaysia (Table 1). Three Sarawak pepper varieties which are 'Kuching', 'Semenggok Aman' and 'Semenggok Emas' were selected to be used in this study. Nine spikes of each three vines were randomly selected. The plant canopy does not affect the formation of spikes and fruits (Satheeshan, 2000). The numbers of male flower, female flower and hermaphrodite in each spike were observed and calculated under 3D Keyence microscope to determine the flower composition. The mean of flower composition percentage of nine spikes of each farm was then plotted accordingly. The selection of vines was based on their height and yielding ability and free from pests and diseases. The vines were in the age group of one until five years old. They were grown under open conditions and were rain fed.

RESULTS AND DISCUSSION

Farming Practices and Problem Encountered by Farmers

As shown in Table 1 and Figure 1, there are four main varieties of pepper planted in Sarawak which are 'Kuching', 'Semenggok Aman', 'Semenggok Emas' and 'India' varieties where the most planted variety is 'Semenggok Aman'. This variety was released on 12 August 2006 in Sri Aman Sarawak by pepper research and development (R&D) team from Agriculture Research Centre, Semenggok, Sarawak.

'Semenggok Aman' produced a good fruit set, bigger berries and longer fruit spikes as compared to 'Kuching'. Moreover, this variety is proven to be tolerant to pepper weevil (*Lophobaris piperis* M.), known as stem borer. In terms of chemical quality, 'Semenggok Aman' contains high piperine, oleoresin, volatile and non-volatile oils compared to other cultivar varieties planted in Sarawak, followed by 'Semenggok Emas' and 'Kuching' (Malaysian Pepper Board, 2013).

Each cultivar has different characteristics (Table 2) and the major characteristics can be shown from their terminal shoot, where the tip is light purple in colour and leaves are ovate lanceolate in shape for 'Kuching' cultivar, with length: width ratio of 1.93 (Paulus & Sim, 2009 as cited in Paulus et al., 2011) and flower spike is pale yellow in colour (Figure 2a). 'Kuching' pericarp is the thinnest of all three cultivars. As for 'Semenggok Emas', the terminal shoot tip has intermediate anthocyanin coloration where the leaves ovate-lanceolate in shape with length: width ratio of 2.07 (Paulus & Sim, 2009 as cited in Paulus et al., 2011) and flower spike is yellow to golden yellow in colour (Figure 2c). Meanwhile for 'Semenggok Aman', the terminal shoot tip has intermediate anthocyanin coloration and the leaves are ovate in shape with length: width ratio of 1.52 (Paulus & Sim, 2009 as cited in Paulus et al., 2011), and flower spike is light green in colour (Figure 2b).

Table 1
Pepper farms location in Sarawak

Farms	Division	District	Location of farm	Cultivars
F1	Miri	Miri	Sg. Siam	Semenggok Aman, Semenggok Emas, Kuching
F2	Miri	Miri	Sg. Nakat	Semenggok Aman, Semenggok Emas, Kuching
F3	Miri	Miri	Sg, Merah	Semenggok Aman, Semenggok Emas, Kuching
F4	Sibu	Bintangor	Sg. Bakong	Semenggok Aman,Kuching
F5	Sibu	Julau	Nanga Bekiok	Semenggok Emas, Kuching
F6	Sibu	Julau	Nanga Bekiok	Semenggok Aman, Kuching
F7	Serian	Serian	Mapu Tragu	Semenggok Aman, Semenggok Emas, Kuching
F8	Serian	Serian	Bunan Punok	Semenggok Aman, Semenggok Emas, Kuching
F9	Serian	Serian	Bunan Gega	Semenggok Aman, Semenggok Emas, Kuching
F10	Sarikei	Sarikei	Sg. Rusa	Kuching
F11	Sarikei	Pakan	Lubuk Embawang	Semenggok Aman, Semenggok Emas, Kuching
F12	Sarikei	Pakan	Rh. Akun,Supi	Semenggok Aman, Semenggok Emas, Kuching
F13	Sri Aman	Sri Aman	Lubuk Ju	Semenggok Aman, Semenggok Emas, Kuching
F14	Sri Aman	Sri Aman	Lubuk Ju	Semenggok Aman, Semenggok Emas, Kuching
F15	Sri Aman	Sri Aman	Rh. Sherit,Undop	Semenggok Aman, Semenggok Emas, Kuching
F16	Kuching	Serikin	Jagoi	Semenggok Aman, Semenggok Emas, Kuching
F17	Kuching	Bau	Stass	Semenggok Aman
F18	Kuching	Bau	Stass	Semenggok Aman

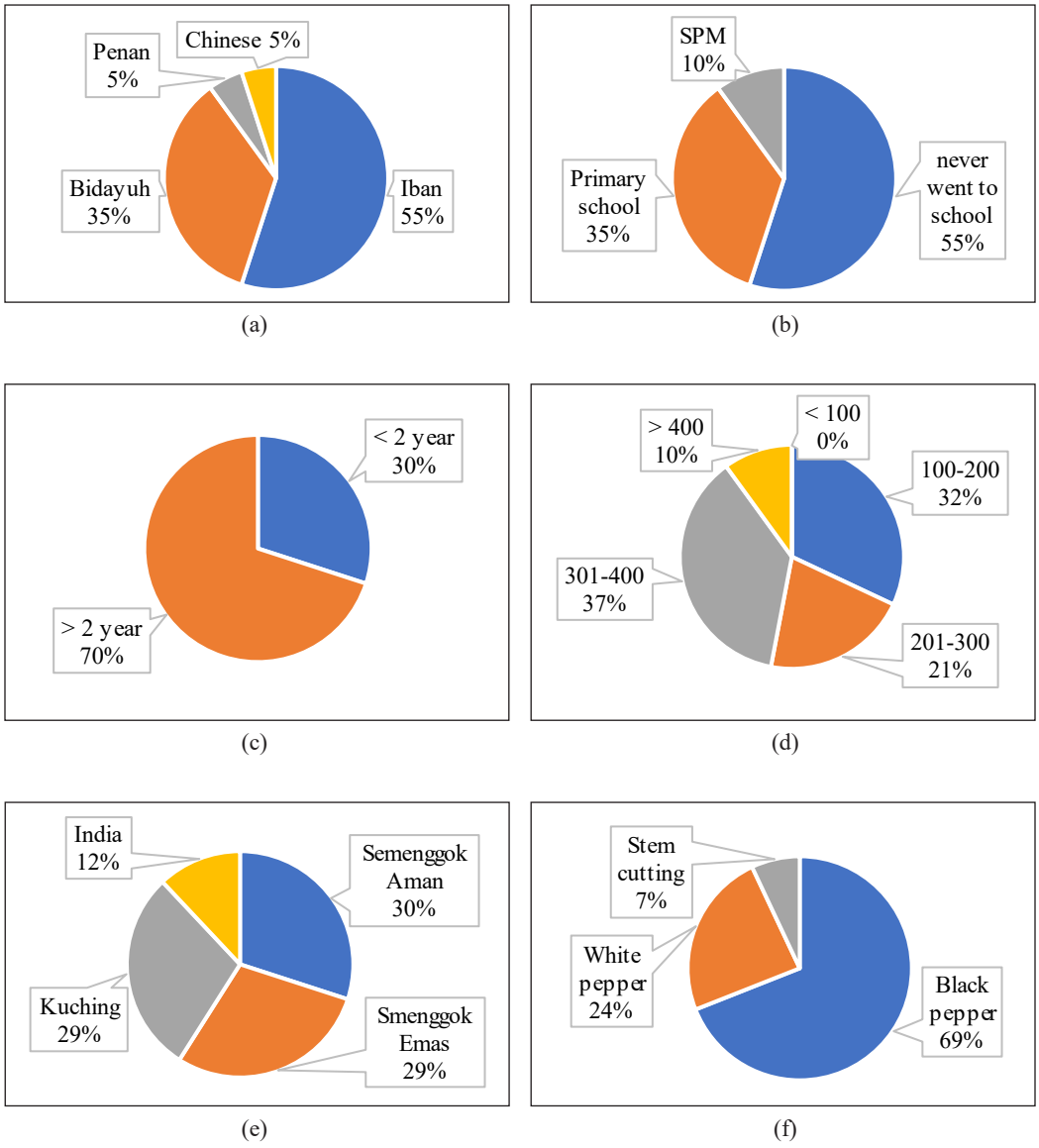


Figure 1. Pepper farming status in Sarawak. (a) ethnicity of pepper farmers; (b) education level of pepper farmers; (c) period establishment of pepper farm; (d) number of pepper vines planted in the farm; (e) type of pepper varieties planted in the farm; and (f) type of pepper products produced by pepper farmers

As for the farm management status, 90% of the farmers practice two times maintenance per month mostly for weeding, fertilization and pruning (Figure 3a-b). There are five main problems encountered by the farmers (Figure 3c). Up to 29% farmers counted diseases as their major problem in their farm, followed by 28% on inconsistent price of pepper commodity. Apart from the major problems, 21% of them

also agreed that the un-synchronization of berries formation also became a significant problem. Meanwhile, 12% of farmers agreed that they had a problem in applying fertilizer for their vine and 10% of them agreed there was un-synchronization of harvesting. Farmers also agreed that they were having spike shedding problems during flower blooming season. Basically, the farmers were seeking advice from MPB to address the problems (Figure 3d).

Table 2
Characteristics comparison between three Sarawak pepper varieties

Characteristics	**Variety**		
	Kuching	**Semenggok Emas**	**Semenggok Aman**
Green berry yield (kg/vine/year)	6-8	6-8	6-8
% Driage (conversion ration) Black pepper	33	31	33
% Driage (conversion ration) white pepper	24	22	22
Weight of 100 mature green berries (g)	13.8	15.6	15.7
Length of fruit spike (cm)	9.7	9.9	10.1
Chemical quality:			
% piperine	3.5	3.4	5.4
% oleoresin	11.0	11.0	15.5
% volatile oil	2.8	3.0	3.8
% non-volatile oil	7.9	8.0	11.5
Harvesting rounds per season	4-6	2-3 (more uniform ripening)	2-3 (more uniform ripening)
Susceptibility to *Phytophthora* foot rot disease	Highly susceptible	Susceptible	Less susceptible
Susceptibility to black berry disease	Highly susceptible	Tolerant	Tolerant
Susceptibility to pepper weevil	Susceptible	Less susceptible	Less susceptible

Source: Malaysian Pepper Board (2013)

(a) (b) (c)

Figure 2. Types of pepper spike in three different cultivar varieties. (a) Kuching, pale yellow in colour; (b) Semenggok Aman, light green in colour; and (c) Semenggok Emas, yellow to golden in colour

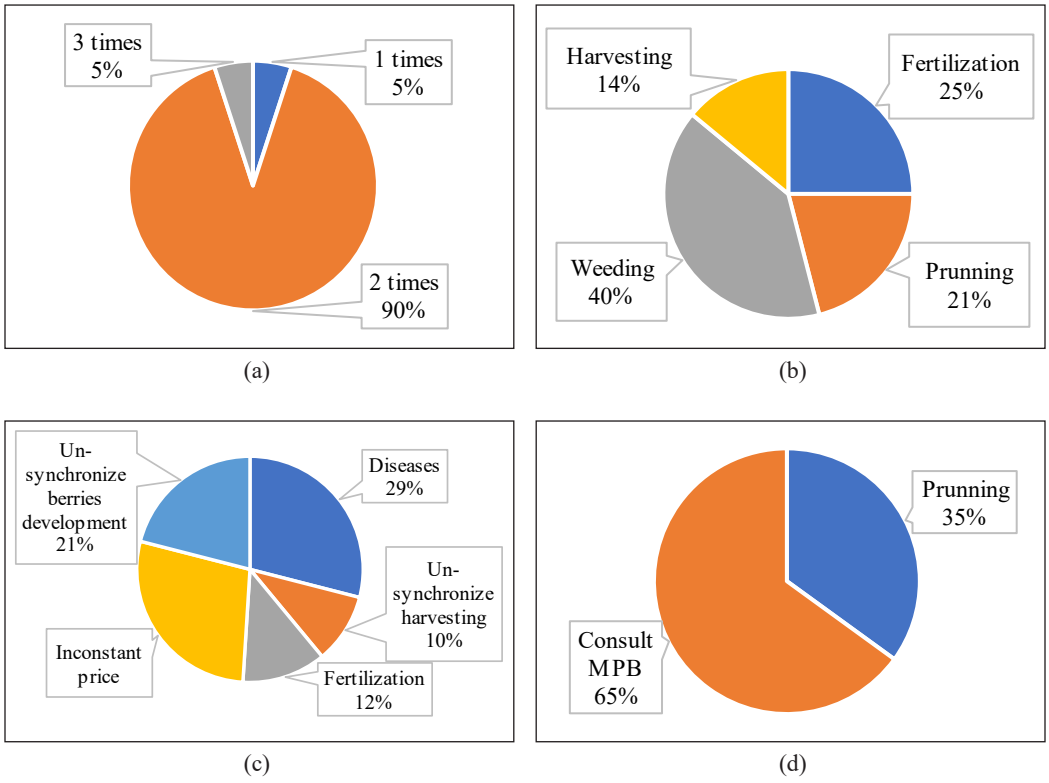


Figure 3. Pepper farm management status and problems encountered by pepper farmers in Sarawak. (a) frequency of vines maintenance in a month; (b) type of vines maintenance activity; (c) problems encountered by the pepper farmers; and (d) methods of solving problems encountered in pepper farms

Flower Composition between Three Different Varieties

Pepper flowers may be hermaphrodite or unisexual which is male and female (Figure 4). The results showed that the composition of flower varied between varieties, where the flower composition in each variety was different from dominantly female to purely bisexual (Parthasarathy et al., 2010). Flower compositions of different

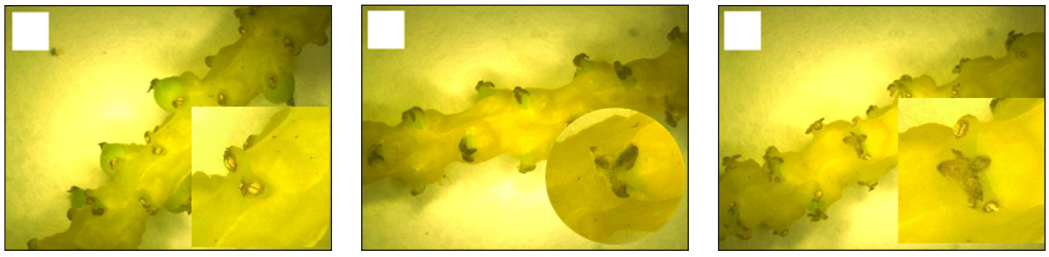
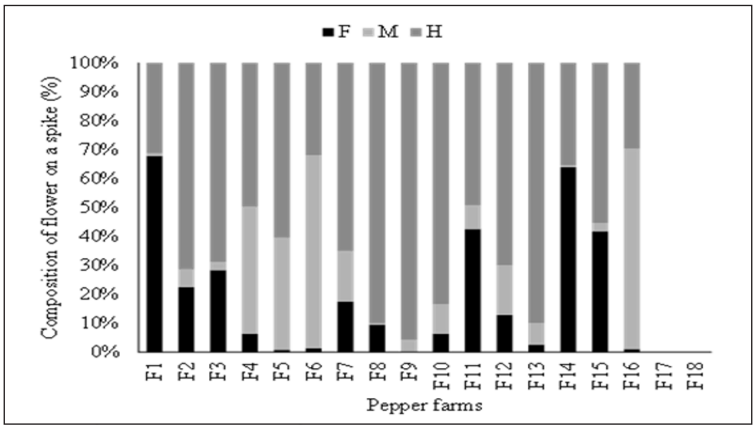
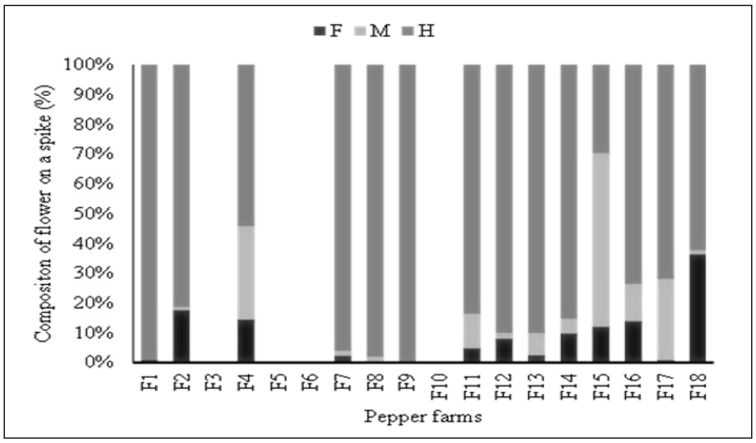


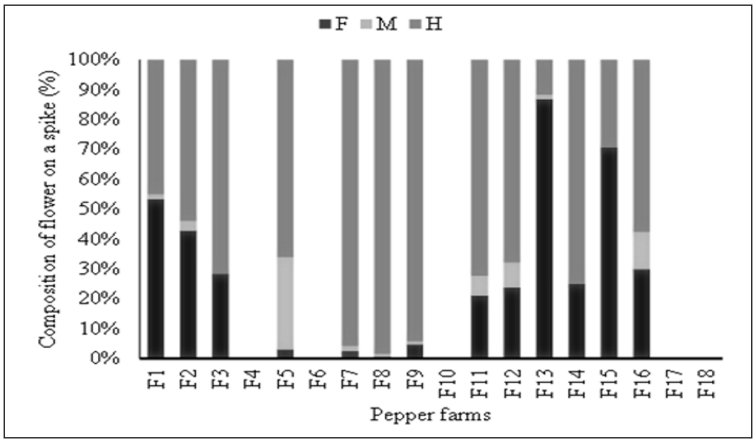
Figure 4. Type of flower on pepper spike. (a) male flower, only stamens are visible between the bracts; (b) female flower, only stigma is visible between the bracts; and (c) hermaphrodite flower, stamens are on both sides of the sigma



(a)



(b)



(c)

Figure 5. Composition of female (F), male (M) and hermaphrodite (H) flowers on different pepper varieties spikes. (a) Kuching pepper variety; (b) Semenggok Aman pepper variety; and (c) Semenggok Emas pepper variety

varieties were presented in Figure 5. The result showed that 'Semenggok Emas' variety at F13 had the highest percentage of female flowers (70.6%) followed by 'Kuching' variety with 69.5% of female flowers. Whereas, 'Semenggok Aman' variety had the lowest female percentage (36.5%). Meanwhile, 'Kuching' varieties had the highest percentage of male flower (69.3 %) located at F16 as compared to 'Semenggok Aman' and 'Semenggok Emas' but had the lowest percentage of the hermaphrodite flower. From the previous study, the percentage of hermaphrodite flowers in the plant varied according to the growth flush and regions (Hallad, 1991). The production of male flowers in spike resulted reduction of crop yield (Venugopal et. al., 2013). However, flower structure in pepper is likely to be influenced by the packaging of flowers in the inflorescence itself and therefore berries productivity is highly dependent on the growth and flowering behaviour of the vine (Satheeshan, 2000). In general, high percentage of bisexual flowers or hermaphrodite flowers is essential for effective pollination and fruit set (Ravindran et al., 2000) where the predominance of the female flowers in each spike is reported as the major cause of pollination failure and subsequent spike shedding instead of producing berries. As there are more than one hormone in the regulation pathway of black pepper, it is not easy to indicate the possible crosstalk between the plant hormones in the fruit development stages (Khew et al., 2019). Khew et al. (2019) also stated that salicylic acid played decisive roles in flowering and fruit set, whereas auxin, gibberellins and cytokinins played roles predominantly in the early fruit development stages during cell division and expansion. Abscisic acid (ABA) appears to play a role in fruit maturation and ripening in the fruit development process.

CONCLUSION

Based on the survey conducted, the major constrains faced by the farmers were unsynchronization of berries production at one time that can be related with flower compositions where a smaller number of hermaphrodite flowers were being observed at the surveyed farms. Thus, the initiation of hermaphrodite flowers through exogenous hormones application is very important to ensure the synchronisation of pepper vine, thus the production of berries could be increased.

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